Table 12.1 - Renewable Energy Impacts Calculation

Conversion Formula:
Step 1 *Capacity (A) x Capacity Factor (B) x Annual Hours (C) = Annual Electricity Generation (D)*
Step 2 *Annual Electricity Generation (D) x Competing Heat Rate (E) = Annual Output (F)*
Step 3 *Annual Output (F) x Emissions Coefficient (G) = Annual Emissions Displaced (H)*

Technology	**Wind**	**Geothermal**	**Biomass**	**Hydropower**	**PV**	**Solar Thermal**
(A) Capacity (kW)	4,290,000	2,860,000	1,770,000	79,450,000	40,000	330,000
(B) Capacity Factor (%)	36.0%	90.0%	80.0%	43.6%	22.5%	24.4%
(C) Annual Hours	8,760	8,760	8,760	8,760	8,760	8,760
(D) Annual Electricity Generation (kWh)	13,528,944,000	22,548,240,000	12,404,160,000	303,448,152,000	78,840,000	705,355,200
(E) Competing Heat Rate (Btu/kWh)	10,201	10,201	10,201	10,201	10,201	10,201
(F) Annual Output (Trillion Btu)	138	230	127	3,095	1	7
(G) Carbon Coefficient (MMTCB/Trillion Btu)	0.01783	0.01783	0.01783	0.01783	0.01783	0.01783
(H) Annual Carbon Displaced (MMTC)	2.461	4.101	2.256	55.192	0.014	0.128

Sources: Capacity: EIA, *Annual Energy Outlook 2003*, DOE/EIA-0383 (2003) (Washington, D.C., January 2003), Table A17, 2001.
Capacity Factors: Hydropower calculated from EIA, Annual Energy Outlook 2003, DOE/EIA-0383 (2003) (Washington, D.C., January 2003), Table A17, 2001. All others based on DOE, Renewable Energy Technology Characterizations, EPRI TR-109496, 1997 and Program data.
Competing Heat Rate: EIA, *Annual Energy Review 2001*, DOE/EIA-0384(2001) (Washington, D.C., November 2002), Table A6.
Carbon Coefficient: DOE, GPRA2003 Data Call, Appendix B, page B-16, 2003.

Notes
Capacity values exclude combined-heat-and-power (CHP) data but include end-use sector (industrial and commercial) non-CHP data.

Table 12.2 - Number of Home Electricity Needs Met Calculation

Conversion Formula: *Step 1* *Capacity (A) x Capacity Factor (B) x Annual Hours (C) = Annual Electricity Generation (D)*
Step 2 *Annual Electricity Generation (D) / Average Consumption (E) = Number of Households (F)*

Technology	**Wind**	**Geothermal**	**Biomass**	**Hydropower**	**PV**	**Solar Thermal**
(A) Capacity (kW)	4,290,000	2,860,000	1,770,000	79,450,000	40,000	330,000
(B) Capacity Factor (%)	36.00%	90.00%	80.00%	43.6%	22.50%	24.4%
(C) Annual Hours	8,760	8,760	8,760	8,760	8,760	8,760
(D) Annual Electricity Generation (kWh)	13,528,944,000	22,548,240,000	12,404,160,000	303,448,152,000	78,840,000	705,355,200
(E) Average Annual Household Electricity Consumption (kWh)	11,301	11,301	11,301	11,301	11,301	11,301
(F) Number of Households	1,197,146	1,995,172	1,097,577	26,850,487	6,976	62,415

Sources: Capacity: EIA, *Annual Energy Outlook 2003*, DOE/EIA-0383 (2003) (Washington, D.C., January 2003), Table A17, 2001.
Capacity Factors: Hydropower calculated from EIA, Annual Energy Outlook 2003, DOE/EIA-0383 (2003) (Washington, D.C., January 2003), Table A17, 2001. All others based on DOE, Renewable Energy Technology Characterizations, EPRI TR-109496, 1997 and Program data.
Household electricity Consumption: EIA, *Annual Energy Outlook 2003*, DOE/EIA-0383 (2003) (Washington, D.C., January 2003), Tables A4 and A8, 2001.

Notes
Capacity values exclude combined-heat-and-power (CHP) data but include end-use sector (industrial and commercial) non-CHP data.

Table 12.3 - Coal Displacement Calculation

Conversion Formula:	*Step 1*	*Capacity (A) x Capacity Factor (B) x Annual Hours (C) = Annual Electricity Generation (D)*
	Step 2	*Annual Electricity Generation (D) x Competing Heat Rate (E) = Total Output (F)*
	Step 3	*Total Output (F) / Fuel Heat Rate (G) = Quantity Fuel (H)*

Technology	**Wind**	**Geothermal**	**Biomass**	**Hydropower**	**PV**	**Solar Thermal**
(A) Capacity (kW)	4,290,000	2,860,000	1,770,000	79,450,000	40,000	330,000
(B) Capacity Factor (%)	36.00%	90.00%	80.00%	43.6%	22.50%	24.4%
(C) Annual Hours	8,760	8,760	8,760	8,760	8,760	8,760
(D) Annual Electricity Generation (kWh)	13,528,944,000	22,548,240,000	12,404,160,000	303,448,152,000	78,840,000	705,355,200
(E) Competing Heat Rate (Btu/kWh)	10,201	10,201	10,201	10,201	10,201	10,201
(F) Total Input (Btu)	138,008,757,744,000	230,014,596,240,000	126,534,836,160,000	3,095,474,598,552,000	804,246,840,000	7,195,328,395,200
(G) Coal Heat Rate (Btu per short ton)	20,511,000	20,511,000	20,511,000	20,511,000	20,511,000	20,511,000
(H) Coal (short tons)	6,728,524	11,214,207	6,169,121	150,917,781	39,211	350,803

Sources: Capacity: EIA, *Annual Energy Outlook 2003*, DOE/EIA-0383 (2003) (Washington, D.C., January 2003), Table A17, 2001.
Capacity Factors: Hydropower calculated from EIA, Annual Energy Outlook 2003, DOE/EIA-0383 (2003) (Washington, D.C., January 2003), Table A17. All others based on DOE, Renewable Energy Technology Characterizations, EPRI TR-109496, 1997 and Program data.
Conversion Efficiency: EIA, *Annual Energy Review 2001*, DOE/EIA-0384(2001) (Washington, D.C., November 2002), Table A6.
Heat Rate: EIA, *Annual Energy Outlook 2003*, DOE/EIA-0383 (2003) (Washington, D.C., January 2003), Table H1.

Notes:
Capacity values exclude combined-heat-and-power (CHP) data but include end-use sector (industrial and commercial) non-CHP data.
Competing heat rate from Fossil-Fueled Steam-Electric Plants heat rate.

Table 12.4 - National SO_2 and Heat Input Data

	1980	1985	1990	1999	2000
SO_2 (lbs)	34,596,164,000	32,184,330,000	31,466,762,000	23,671,356,200	22,404,221,912
Heat (Btu)	17,859,930,911	18,414,434,444	19,684,248,424	21,866,064,735	25,598,347,988
SO_2 Heat Factor (lb/Btu)	1.937	1.748	1.599	1.083	0.875

Source: EPA, *Acid Rain Program Compliance Report 2001, Emission Scorecard*, updated April 2003, Table A1, http://www.epa.gov/airmarkets/emissions/score01/index.html

Notes:
Data include all Phase I and Phase II units.

Table 12.5 - SO_2, NOx, CO_2 Emission Factors for Coal Fired and Non-Coal Fired Title IV Affected Units

	1996	1997	1998	1999	2000	2001
SO_2 (lbs/Btu)						
Coal	1.241	1.245	1.222	1.166	1.036	1.008
Non-Coal	0.246	0.256	0.318	0.267	0.200	0.220
Total	1.096	1.093	1.058	0.999	0.875	0.843
NO_x (lbs/Btu)						
Coal	0.568	0.559	0.532	0.485	0.444	0.424
Non-Coal	0.221	0.234	0.251	0.244	0.210	0.176
Total	0.518	0.509	0.481	0.440	0.399	0.372
CO_2 (lbs/Btu)						
Coal	206.136	205.537	205.677	205.586	205.646	205.624
Non-Coal	132.731	130.804	131.685	132.001	133.095	130.159
Total	195.476	194.056	192.256	191.956	191.678	189.805

Source: EPA, *Acid Rain Program Compliance Report 2001, Emission Scorecard*, updated April 2003, Table 1, http://www.epa.gov/airmarkets/emissions/score01/index.html

Table 12.6a - Sulfur Dioxide, Nitrogen Oxide, and Carbon Dioxide Emission Factors, 2000 - Electricity Generators

Fuel	Boiler Type/ Firing Configuration	Emission Factors		
		Sulfur Dioxide [1]	Nitrogen Oxides [2]	Carbon Dioxide [3]
Coal and Other Solid Fuels		lbs per ton	lbs per ton	lbs per 10^6 Btu
Petroleum Coke [4]	fluidized bed [5]	39.0 x S	21	225.13
	all others	39.0 x S	21	225.13
Refuse	all types	3.9	5	199.82
Wood	all types	0.08	1.5	0
Petroleum and Other Liquid Fuels		lbs per 10^3 gal	lbs per 10^3 gal	lbs per 10^6 Btu
Residual Oil[6]	tangential	157.0 x S	32	173.72
	vertical	157.0 x S	47	173.72
	all others	157.0 x S	47	173.72
Distillate Oil[6]	all types	157.0 x S	24	161.27
Methanol	all types	0.05	12.4	138.15
Propane (liquid)	all types	86.5	19	139.04
Coal-Oil Mixture	all types	185.00 x S	50	173.72
Natural Gas and Other Gaseous Fuels		lbs per 10^6 cf	lbs per 10^6 cf	lbs per 10^6 Btu
Natural Gas	tangential	0.6	170	116.97
	all others	0.6	280	116.97
Blast Furnace Gas	all types	950	280	116.97

Source: EIA, *Electric Power Annual 2001*, DOE/EIA-0348(01) (Washington, D.C., March 2003), Tables A1, A3.

Notes:

[1] Uncontrolled sulfur dioxide emission factors. "x S" indicates that the constant must be multiplied by the percentage (by weight) of sulfur in the fuel. Sulfur dioxide emission estimates from facilities with flue gas desulfurization equipment are calculated by multiplying uncontrolled emission estimates by one minus the reported sulfur removal efficiencies. Sulfur dioxide emission factors also account for small quantities of sulfur trioxide and gaseous sulfates.

[2] Parenthetic values are for wet bottom boilers; otherwise dry bottom boilers. If bottom type is unknown, dry bottom is assumed. Emission factors are for boilers with a gross heat rate of 100 million Btu per hour or greater.

[3] Uncontrolled carbon dioxide emission estimates are reduced by 1% to account for unburned carbon.

[4] Emission factors for petroleum coke are assumed to be the same as those for anthracite. If the sulfur content of petroleum coke is unknown, a 6 percent sulfur content is assumed.

[5] Sulfur dioxide emission estimates from fluidized bed boilers assume a sulfur removal efficiency of 90%.

[6] Oil types are categorized by Btu content as follows: heavy (greater than or equal to 144,190 Btu per gallon), and light (less than 144,190 Btu per gallon). cf = Cubic Feet. gal = U.S. Gallons. lbs = Pounds.

Table 12.6b - Sulfur Dioxide, Nitrogen Oxide, and Carbon Dioxide Emission Factors, 2000 - Combined Heat and Power Producers

Fuel	Boiler Type/ Firing Configuration	Emission Factors		
		Sulfur Dioxide [1]	Nitrogen Oxides [2]	Carbon Dioxide [3]
Coal and Other Solid Fuels		lbs per ton	lbs per ton	lbs per 10^6 Btu
Agricultural Waste	all types	0.08	1.2	0
Black Liquor	all types	7	1.5	0
Chemicals	all types	7	1.5	0
Closed Loop Biomass	all types	0.08	1.5	0
Internal	all types	0.08	1.5	0
Liquid Acetonitrile Waste	all types	7	1.5	150.76
Liquid Waste	all types	2.8	2.3	163.29
Municipal Solid Waste	all types	1.7	5.9	189.48
Petroleum Coke	all types	39.00 x S	14	225.13
Pitch	all types	30.00 x S	11.1	0
RailRoad Ties	all types	0.08	1.5	0
Red Liquor	all types	7	1.5	0
Sludge, Sludge Wood/Waste	all types	2.8	5	0
Spent Sulfite Liquor	all types	7	1.5	0
Straw	all types	0.08	1.5	0
Sulfur	all types	7	0	0
Tar Coal	all types	30.00 x S	11.1	0
Tires	all types	38.00 x S	21.7	0
Waste Byproducts	all types	1.7	2.3	163.29
Waste Coal	all types	38.00 x S	21.7	0
Petroleum and Other Liquid Fuels		lbs per 10^3 gal	lbs per 10^3 gal	lbs per 10^6 Btu
Heavy Oil[4]	all types	157.00 x S	47	173.72
Light Oil[4]	all types	142.00 x S	20	159.41
Diesel	all types	142.00 x S	20	161.27
Kerosene	all types	142.00 x S	20	159.41
Butane (liquid)	all types	0.09	21	143.20
Fish Oil	all types	0.5	12.4	0
Methanol	all types	0.5	12.4	138.15
Oil Waste	all types	147.00 x S	19	163.61
Propane (liquid)	all types	0.5	19	139.04
Sludge Oil	all types	147.00 x S	19	0
Tar Oil	all types	162.70 x S	67	0
Waste Alcohol	all types	0.5	12.4	138.15
Natural Gas and Other Gaseous Fuels		lbs per 10^6 cf	lbs per 10^6 cf	lbs per 10^6 Btu
Natural Gas	all types	0.6	280	116.97
Butane (Gas)	all types	0.6	21	143.20
Hydrogen	all types	0	550	0
Landfill Gas	all types	0.6	550	115.12
Methane	all types	0.6	550	115.11
Other Gas	all types	0.6	550	141.54
Propane (Gas)	all types	0.6	19	139.04

Source: EIA, *Electric Power Annual 2001*, DOE/EIA-0348(01) (Washington, D.C., March 2003), Tables A1, A3.

Notes:

[1] Uncontrolled sulfur dioxide emission factors. "x S" indicates that the constant must be multiplied by the percentage (by weight) of sulfur in the fuel. Sulfur dioxide emission estimates from facilities with flue gas desulfurization equipment are calculated by multiplying uncontrolled emission estimates by one minus the reported sulfur removal efficiencies. Sulfur dioxide emission factors also account for small quantities of sulfur trioxide and gaseous sulfates.

[2] Parenthetic values are for wet bottom boilers; otherwise dry bottom boilers. If bottom type is unknown, dry bottom is assumed. Emission factors are for boilers with a gross heat rate of 100 million Btu per hour or greater.

[3] Uncontrolled carbon dioxide emission estimates are reduced by 1% to account for unburned carbon.

[4] Oil types are categorized by Btu content as follows: heavy (greater than or equal to 144,190 Btu per gallon), and light (less than 144,190 Btu per gallon). cf = Cubic Feet. gal = U.S. Gallons. lbs = Pounds.

Table 12.7 - Global Warming Potentials (GWP)

(100-year time horizon)

Gas	GWP
Carbon dioxide (CO2)	1
Methane (CH4)[1]	23
Nitrous oxide (N2O)	296
HFC-23	12,000
HFC-32	550
HFC-125	3,400
HFC-134a	1,300
HFC-143a	4,300
HFC-152a	120
HFC-227ea	3,500
HFC-236fa	9,400
HFC-4310mee	1,500
CF4	5,700
C2F6	11,900
C4F10	8,600
C6F14	9,000
SF6	22,200

Source: EPA, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2000*, EPA 430-R-02-003 (Washington, D.C., April 2002), Table ES-6.

Notes:

The GWP of a greenhouse gas is the ratio of global warming, or radiative forcing – both direct and indirect – from one unit mass of a greenhouse gas to that of one unit mass of carbon dioxide over a period of time.

GWP from Intergovernmental Panel and Climate Change (IPCC) Third Assessment Report (TAR).

[1] The methane GWP includes direct effects and those indirect effects due to the production of tropospheric ozone and stratospheric water vapor. The indirect effect due to the production of CO2 is not included.

Table 12.8 - Approximate Heat Content of Selected Fuels for Electric Power Generation

Fossil Fuels [1]	
Residual Oil (million Btu per barrel)	6.287
Distallate Oil (million Btu per barrel)	5.825
Natural Gas (Btu per cubic ft)	1,019
Coal (million Btu per Short Ton)	20.511

Biomass Materials [2]	
Switchgrass Btu per pound	7,341
Bagasse, Btu per pound	6,065
Rice Hulls, Btu per pound	6,575
Poultry Litter, Btu per pound	6,187
Solid wood waste, Btu per pound	6-8,000

Sources

1. EIA, *Annual Energy Outlook 2003*, DOE/EIA-0383 (2003) (Washington, D.C., January 2003), Table H1.
2. Animal Waste Screening Study, Electrotek Concepts, Inc., Arlington, Va. June 2001.

Table 12.9 - Approximate Heat Rates for Electricity

(Btu per Kilowatthour)

	1980	1990	2000	2001
Fossil-Fueled Steam-Electric Plants[1]	10,388	10,402	10,201	10,201
Nuclear Steam-Electric Plants	10,908	10,582	10,429	10,442
Geothermal Energy Plants[2]	21,639	21,096	21,017	21,017

Source: EIA, *Annual Energy Review 2001*, DOE/EIA-0384(01) (Washington, D.C., November 2002), Table A6.

Notes:

[1] Used as the thermal conversion factor for hydroelectric power generation, and for wood and waste, wind and solar energy consumed for the generation of electricity.

[2] Used as the thermal conversion factor for geothermal energy consumed for the generation of electricity

Table 12.10 - Heating Degree Days by Month

	1980	1990	2000	2001	Normal[1]
January	887	728	886	915	948
February	831	655	643	720	768
March	680	535	494	658	611
April	338	321	341	310	339
May	142	184	115	113	150
June	49	29	29	29	36
July	5	6	12	6	7
August	10	10	12	4	13
September	54	56	69	76	69
October	316	246	244	264	271
November	564	457	610	402	528
December	831	789	1,005	700	836
Total	4,707	4,016	4,460	4,197	4,576

Source: EIA, *Annual Energy Review 2001,* DOE/EIA-0384(01) (Washington, D.C., November 2002), Table 1.7.

Notes:

[1] Based on calculations of data from 1961-1990

Table 12.11 - Cooling Degree Days by Month

	1980	1990	2000	2001	Normal[1]
January	9	15	10	3	7
February	4	14	10	10	7
March	13	21	25	10	16
April	23	29	28	50	31
May	95	86	131	113	95
June	199	234	221	225	208
July	374	316	284	317	317
August	347	291	302	323	287
September	192	172	156	144	154
October	42	57	50	50	52
November	10	16	8	19	13
December	5	9	4	11	7
Total	1,313	1,260	1,229	1,275	1,193

Source: EIA, *Annual Energy Review 2001,* DOE/EIA-0384(01) (Washington, D.C., November 2002), Table 1.8.

Notes:
[1] Based on calculations of data from 1961-1990